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A REVIEW OF RENEWABLE ENERGY RESOURCES IN PAKISTAN

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Electricity performs an integral part in the economical development and national growth of country. Unfortunately, Pakistan is going through its worst period of power shortages. It is also adversely affecting the production capacity of thousands of industrial units in the country. The foremost cause of "load shedding" is that Pakistan produces major portion of energy from fossil fuels, its price and demand is continuously increasing with the passage of time. Pakistan has wide range of renewable power sources like biomass and wind energy, solar energy, hydel etc. Synthetic Natural Gas, coal, radioactive minerals & oil are modest energy resources whereas wind, hydel, solar, biomass etc are bountiful energy resources. In this article, potential of different resources for electricity production in Pakistan has been studied as well as different technologies how energy can be extracted from biomass. It is envisaged that energy/electricity crisis can be overcome by the efficient utilization of these Resources

Keywords: Electricity, Resources, Load shedding, Fossil Fuel, Potential, Biomass

INTRODUCTION

Electricity performs an integral part in the economical development and national growth of country as shown in figure 1 [1].Pakistan is facing the worst crisis of electricity.
In 1947, Pakistan has potential for a production of 60MW electricity to meet the demands of 31.5 million people. But now due to electricity shortage, power crisis had enhanced to 4000MW in 2008[2]. Rural areas are facing load shedding approximately 20 hours as compared to, in cities approximately 14 hours per day. According to estimation of Pakistan Electric Power Company, in May 2012, gap between demand and supply has been increased up to 6,000MW [1]. Due to regular power shortage, "load shedding" has become a general event. In addition to continuously increasing population from last few years, no valuable progress has been taken in field of electricity production like to enhance capacity of existing power plant or install new power plant. The foremost cause of "load shedding" is that Pakistan produces major portion of energy from fossil fuels, its price is continuously increasing with the passage of time and needs. Pakistan has to import fossil fuels to meet power requirements. This shortage of electricity would be worse in future if no considerable steps have been taken to eliminate the variation between requirement and delivered amount of electricity as shown in figure 2.
The major technological reasons of the shortage of electricity in Pakistan are

- Unsatisfactory performance of Power production plants
- Power distribution scheme insufficient to overcome load
- Power distribution system and connected appliances not capable to bear the load
- Deficiency of satisfactory planning
- Revenue Shortage
- Dilapidated transmission network ,distribution and Transmission losses
- Poor maintenance of existing Plants

The main reasons of shortage of electricity respective to administrative are

- Flawed administrative information scheme
- Stoppage of project and future scheduling
- Political
- Non exploitation of renewable Resources

Moreover, the use of fossil fuels evolves carbon dioxide and further detrimental gases such as CO_2, methane and nitrous oxide etc. which cause global warming and ozone layer depletion etc. Thus the increasing cost and environmental issues compelled to us to produce energy from renewable power resources. The renewable power resources are environment friendly. Pakistan has wide range of renewable energy sources like wind, biomass, hydel, solar energy, etc. [3, 4]. However wind, hydel, solar, biomass etc are bountiful energy resources [5].

Renewable energy resources: Pakistan has considerable renewable energy resources such as wind, hydro, biomass & solar .Energy from all available coal, gas and renewable energy resources should be extracted to increase power supply and remove gap between required and delivered amount of electricity. The better and efficient use of Renewable energy resources helps in getting rid of load shedding and tackle environmental issues [3]. The status of energy extraction from various sources through the world is given in as shown in table-1.

Coal energy: According to international world coal ranking, Pakistan is at seventh number [5]. Unfortunately, Pakistan meets only 0.79 percent energy demand from coal

in comparison to worldwide average 40 percent [3]. While all over the world, highest amount of electricity is produced from coal as shown in figure 2[6] .Because of continuously increasing energy demand, to get energy from coal has become essential [5]. Total coal reserves in Pakistan are 185,175 million tones as shown in table-2. Among them, Thar coal is the largest coal reserve having 75.5billion tones coal [3]. In Pakistan large no. of coal reserves is lignite. No valuable steps have been taken to get energy from it instead of vast coal reserves. A large part of Pakistan's coal (97 percent) is lignite & smaller part is sub-bituminous. That's why, there is a need to introduce new technology which can use mixture of different varieties of coal (lignite, bituminous & sub bituminous). The Thar coal reserves mostly contain lignite and present in large amount. Contribution of coal for production of energy has enhanced from 6.5 percent to 7.6 (2003-11) [5]. Pakistan has potential to produce approximate 100000MW electricity from coal [3].

Biomass: Biomass is basically a renewable energy resource and has a great share for the reduction of greenhouse effect. After coal, petroleum & SNG, biomass is at the 4th biggest resource of power in the world which contributes to approximate 14% of the world's energy demand. Amongst all the renewable energy resources, biomass is exceptional because it also stores energy efficiently in itself. It is alone energy resource that can efficiently be converted into solid, liquid and gaseous fuel by using different technology. Biomass is an attractive source of energy for production of electricity due to following reasons biomass is a renewable , sustainable and comparatively friendly towards environment, eliminate the need of crude oil, does not share towards the emission of oxides of Sulphure in environment, lower emission of ash,not fluctations in selling price, has CO_2 life cycle [8].Biomass like cotton stalk, wheat straw, & rice husk etc are abundant in Pakistan as shown in table-3. From it energy can be extracted by using direct combustion, biological process & gasification [4]. Approximately 225,000 tones of crop reside are being producing daily [3].

Biogas: Biogas is defined as energy produce from solid waste. Pakistan has a potential of 8.8 to 17.2 billion cubic meters of biogas production from waste annually [3]. 3,500 small size biogas production plants have been manufactured which can fulfill energy requirements of 3,500 households domestically in remote areas of Pakistan. Further three small biogas plants have been manufactured in remote areas of Islamabad which can fulfill energy demands of twenty homes. One thousand cubic meter capacity plant has been designed for installation in cattle colony of Karachi. Biogas can be produced from dung animal. A large amount of animal dung is accessible in Baluchistan, NWP, Punjab and Sindh. According to estimation, approximately 21.35 million cubic meter biogas can be produced from animal dung. From this amount of biogas, Pakistan can fulfill energy needs of 6 million houses. Additionally, daily 45 million tones of fertilizer can be obtained as by-products. Approximately, one million cubic meter animal manure and 50,000 tones solid waste are being producing daily in Pakistan. While 55,000 tones of solid waste are being producing daily in urban areas. Biogas production from waste is best solution to solve the problem of waste disposal as well as meets the energy needs of people domestically [4]. While, in 2000, Pakistani government had started Biogas Support Program & 1200 units have been installed according to this plan. While 10,000 biogas plants are under construction considering that 27 percent biogas can be produced from it [10].

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According to estimation, approximately 21.35 million cubic meter biogas can be produced from animal dung. From this amount of biogas, Pakistan can fulfill energy needs of 6 million houses. Additionally, daily 45 million tones of fertilizer can be obtained as by-products. Approximately, one million cubic meter animal manure and 50,000 tones solid waste are being producing daily in Pakistan. While 55,000 tones of solid waste are being producing daily in urban areas. Biogas production from waste is best solution to solve the problem of waste disposal as well as meets the energy needs of people domestically [4]. While, in 2000, Pakistani government had started Biogas Support Program & 1200 units have been installed according to this plan. While 10,000 biogas plants are under construction considering that 27 percent biogas can be produced from it [10].

Hydel Generation: Hydro power is a sound recognized & Pakistan has great potential to get huge amount of energy from hydropower as shown in figure 4 [11]. In Pakistan, Hydropower capacity is approximated to 50000MW, from which 6,595MW has been established [4]. In 1947, just 10.7MW potential of hydropower has been inherited to Pakistan. Mangla Dam had been constructed in 1967 on Jhelum River. Tarbela Dam had been built in 1977 on Indus River having high capacity of electricity generation [3].
The economically utilizable hydro power capacity in Pakistan is approximated to 20,000MW. In 1998, 4,825MW hydropower plants have been installed at different places like 2,40MW at Warsak, 3,478MW at Tarbela, 1000MW at Mangla as well as small hydropower plant on Canals with capacity 107MW. Various projects were still under construction like 1,450MW at Ghazi Barotha & 184MW at

Chasma [12]. In Pakistan, Industries are facing electricity shortage because of small level of H_2O at various dams [2]. Pakistan has plentiful water sources although just 13 percent has been stored yearly. Hydropower is a sustainable source of energy. Pakistan has this facility but unluckily, we are not making better use of it [3].

Nuclear Power Generation: In world, Pakistan is amongst thirty countries, which have reposed confidence in Nuclear Power plants. In the field of Nuclear power, globally installed capacity was 375,000MW in 2010. 442 plants had been installed in 1995. Vast progress had been done in this area for the production of power. Considerable improvements had been done in it to enhance the efficiency of Nuclear power plant & its availability time has also been enhanced, which means condensed conservancy time. In 1977, 137MW PAEC nuclear plant had been built in Karachi. At this power plant, Canada was technically supporting Pakistan in the field of Development, research and for training opportunities. In 1981, 1st power plant (600MW) had been installed at Kundian near Chashma. After some time, its capacity enhanced 900MW with the corporation of Chinese [12]. In coming years, Pakistan is trying to plan to do further development in Nuclear power field. According to it, Pakistan will be going to use abundant amount of Uranium to make three hundred & fifty tonnes of nuclear fuel yearly. This plan will come into operation from 2015 [3]. If Pakistan makes better & absolute use of all these accessible resources, it can defeat energy crisis effectively.

Solar energy: Pakistan is present in an area of large solar radiation about 15.5×1,014KWh. Pakistan receives large amount of solar radiations every year. Pakistan can ideally get large amount of energy from solar radiations as shown in table-4. In most areas sun shines estimated to be eight to nine hours/day [3].Unfortunately, a huge piece of the population living in rural does not have supply of power since people are living either in a very remote area or it is too much costly to supply in such areas through grid stations. A cheapest source of energy in those areas may be solar energy. Photovoltaic is a device which is use to generate electricity from solar radiations. Akhat Solar limited is manufacturing limited size solar panels whose electricity production capacity is about 2MW. Pakistan Council of Renewable Energy (PCRET) have installed thirteen solar panels of total capacity 26.5KW which is supplying electricity to 124 community centers, schools and houses. PCRET have specially manufactured three thousands solar lanterns to supply electricity to rural areas. In the world, Pakistan is present in the region of the toppest solar insulation. The average solar radiation is 5.5KW/m^2 in more than three hundreds clear days [4].

Wind energy: Wind energy is a vast energy resource in Pakistan, from which Pakistan can get large amount of energy efficiently. The potential of wind energy in Pakistan is approximated to 50000MW [4].A survey report had been presented which representing that Pakistan has a perfect wind corridor in Islamabad, Karachi & Thatta region. To run a turbine, range of minimum wind velocity is needed 3 to 4km per second. Luckily in Pakistan's corridor, wind speed is from 6 to 7.5meter per second, which is ideally perfect speed to run the turbine. Survey report has presented that Pakistan has potential to produce 300,000MW electricity from wind & solar resource as well as can meet somehow demand as shown in figure 5 [13, 14].
With the corporation of Zurlo Enerji engineering which is Turkish company, in Pakistan, 1st 50MW wind Project had been started in Sindh (Jhampir) & finished 5 wind turbines from which one is still uninstalled. Capacity of single turbine was 1.2MW. Fauji fertilizer Company Energy Ltd. (FFCEL) has lunched 49.5MW wind electricity generation projects to Descon Engineering Ltd. (Pakistan) Nordex (Germany). In July 2012, Thirty three numbers of turbines each having 1.5MW capacity has been installed successfully [13].Pakistan has wonderful potential of wind energy. Wind turbines can be installed in remote areas of south, Northern, Sindh and Baluchistan to supply electricity to more than five thousand villages [4]. Unluckily, instead of vast potential of wind energy, we are not getting benefit from it & facing energy crisis. In recent years, wind power resources are broadly utilized to generate power in a number of countries like India, United States, and Spain & Germany etc [15].In the world 30,000MW electricity has been generated from wind energy. According to estimation, 212TW electricity can be generated from wind energy per year in Pakistan as shown in figure 6 [3].

Different Technologies to gain Energy from Biomass/ Coal

Biomass combustion: Biomass direct burning (DB) is usually followed. Rankine cycle, in which steam turbine (ST) is used to run generator. In DB, biomass has been burned; by using its thermal heat steam is produced in boilers. Biomass co-firing is defined as combined burning of energy resources like coal and biomass. Combined combustion is the best choice for power production for the reason that it provides benefit of great investment, developed electricity production system, and high efficiency which need moderately less cost to consider amount of biomass. Due to less N_2 and S amount in biomass in comparison to coal , carbon dioxide life cycle containing renewable resource to electricity production ,biomass combined burning may be a effectual procedure to minimize the oxides of nitrogen and sulphur and detrimental gases in environment [16]. The restriction of this process is that ash having various properties as compared to coal are blended which may cause undesired, best understood ash performance in its application. The solution of this problem is that first do gasification of biomass and enters the syngas into the boiler. In that manner, we can easily adjust equity in the injected amount of coal and biomass and remove ash from it step by step. The negative aspect of it is that one more than required gasifier has to use which increases cost [17].

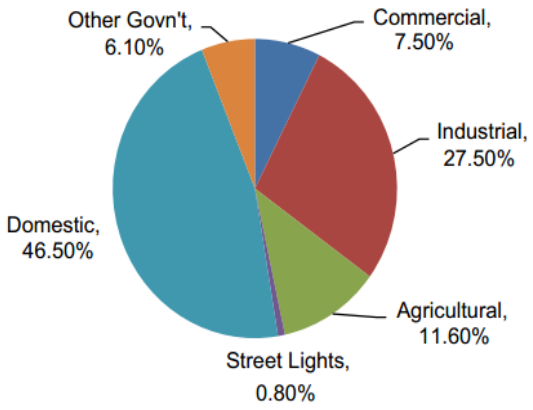

Fig. 1: Electricity consumption by sector, 2010-2011[1]

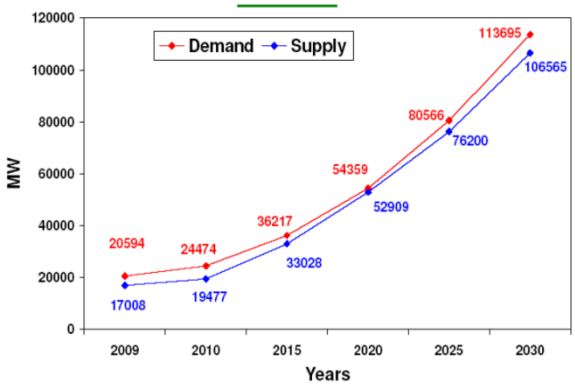

Fig. 2: Peak Demand Projections of Whole country [3]

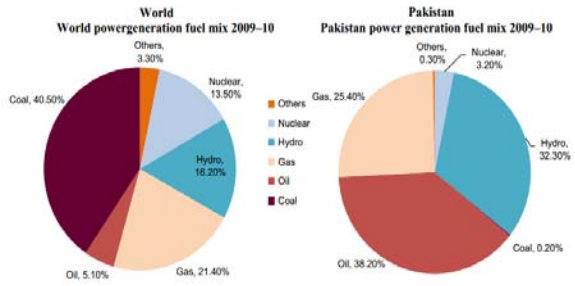

Fig. 3: A comparison of fuel mix in electricity generation [1]

Anaerobic digestion: Anaerobic digestion (AD) is a biological method which is the conversion of solid, liquid biomass to gaseous fuel in the absence of O_2. Anaerobic digestion takes place in the following way [12].

$$C_6H_{10}O_5 + H_2O \rightarrow 3CH_4 + 3CO_2$$

Evolved gas contains CH_4 & CO_2 as well as small amount of additional gas [16]. Biomass can be converted into gas by this method. This process is the breakage of organic matter by action of bacteria. This process can occur in especially prepared anaerobic digester or landfill places [18]. AD is efficient process for treatment of that matter, contains large amount of H_2O (humidity). Feed like municipal solid waste, agriculture and industrial waste is appropriate for AD [16]. Bacteria are prepared at particular conditions and pH. According to the nature of feed, product gas contains different percentage of pure CH_4 gas, generally contains 55 to 75 percent CH_4 gas. This product can be changed into natural gas after treatment, which generally contains 70-90 percent CH_4. The other liquid product of AD process can be send to land to use as a fertilizer and solid fiber used as a soil conditioner [18].

Biomass Pyrolysis: Pyrolysis is a thermal decomposition process that converts biomass in the absence of air, into gaseous (combustible), liquid (oil) & solid (char) product on heating approximate to 500^0C as shown in figure 7 [19]. Flash pyrolysis, which uses elevated temperature & less residence time than fast pyrolysis is likewise aimed at maximizing bio-oil production, with bio-oil yield of 75 to 80 percent as shown in table-5. Bio-oil has a lower heating value of 16MJ/kg & after up gradation, it uses as fuel in Gas turbines, diesel engine & in boilers for production of power. As a liquid has high energy density as compared to solid. If we obtain product in liquid from, there are various advantages like reduces cost of handling, storage & transportation [7]. However, there is need of bit improvements in the product quality to conquer redundant properties like corrosivity, heating value, high viscosity and poor thermal conductivity. There is necessary extensive upgrading to use liquid product as a fuel in combustion engine or for further highly developed applications, upgrading steps like at atmospheric pressure zeolite cracking or at high pressure deoxygenation by catalytic hydrotreating [17]. Further upgrading of bio-oils is that reducing O_2 content & dimishing alkalies through hydrogenation & catalytic cracking [19].

Biomass gasification (BG): Gasification is a process that converts carbon containing feed into product gas by partial oxidation at high temperature. Generally Gasification proceeds in this way

$$C_6H_{12}O_6 + 0.5O_2 \rightarrow 6CO + 5H_2 + 1.85MJ/kg$$

The fuel gas contains different gases like H_2, CO, CH_4, H_2O vapors & trace fraction of heavy hydrocarbon. For partial oxidation, oxidant is generally air, O_2 & steam. According to the composition of feed enters & process used, the gas usually has a heating value in the range of (1/10 to 1/2) of SNG. This gaseous product may be further combust in boiler, where after cleaning or removal of side products can be used as a fuel in engines or gas turbines. Secondly after some treatment, it changes into CH_3OH or H_2.

Thirdly this process can be used for the production of electricity by using product gas to run the turbine, it is comparatively efficient to Rankine Cycle, & has less cost per unit [17].

Integrated Gasification Combined Cycle (IGCC) technology can be used to produce energy it has following

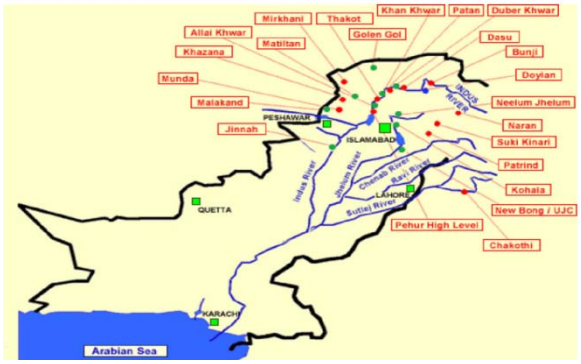

Fig. 4: Identified sites for hydropower generation [11]

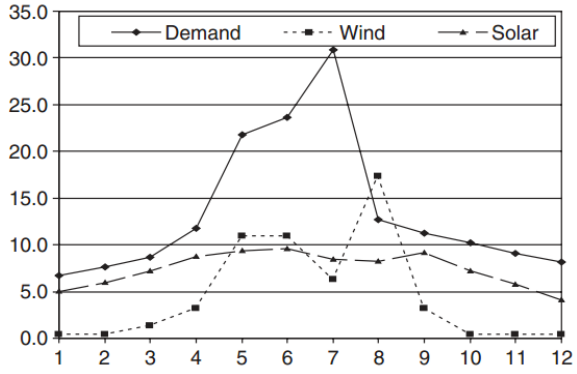

Fig. 5: Monthly electricity demand and solar and wind supply potential [14]

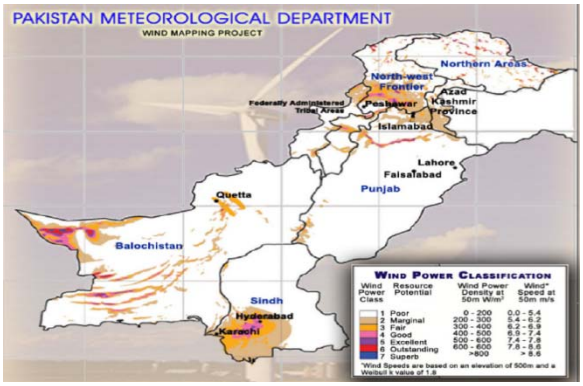

Fig. 6: Wind energy map of Pakistan at height of 50m [11]

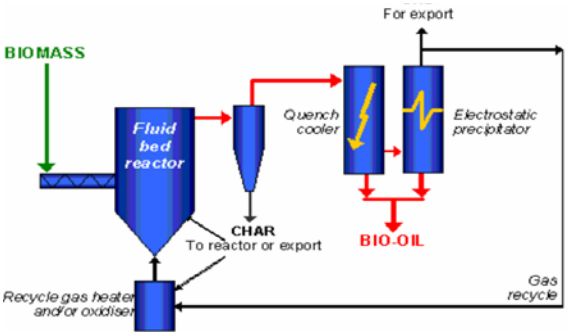

Fig. 7: Fast pyrolysis Process [16]

advantages clean process, syngas can be purified from impurity, before it is used to run turbine, can obtain different variety of products, can eliminate CO_2 pre-combustion, gas used to run turbine will frequently consist of H_2, removed fraction of CO_2 can be used to extract oil from wells as shown in figure 8 [6].

Summary: Biomass burning provides thermal energy or power. BG provides a mixture of gases that can be used for the production of various products like heat, power, SNG, chemicals and combustible fuels. From all these products, if we want to gain only heat and power, at this stage burning & BG process compete to each other. If we just want to get heat, burning process should be preferred. Big scale SNG producing plant by using BG is the most preferable choice. If we just want to gain power, at this step BG & burning process also compete to each other. Nevertheless, due to Carnot's law, BG process can have high efficiency. Its advantage further increases, if fuel cell is entered to the BG process. In addition to, through BG large number of products can be gain like liquids (CH_3OH etc) and gaseous (SNG etc) fuels.

Still BG plays a vital role, if only heat is demanded. Because this process produces "synthetic natural gas" which may be stored, convey for the usage in further process & combust any time when heat is required. Anaerobic Digestion is an efficient process for the treatment of biomass as well as solid waste, which contains large amount of moisture. Because it is a biological process and cannot involve any heat for extraction of energy from matter. In pyrolysis, obtained oil has a lower heating value (16MJ/kg) & after up gradation, it is used as a fuel in Gas turbines, diesel engine & in boilers for production of power. Liquid has high energy density as compared to solid.

If we obtain product in liquid from, there are various advantages like reduces cost of handling, storage & transportation. Cofiring is a preferable choice under considering environment because Coal contains high sulphur content and biomass has lower. Biomass has lower NO_X and SO_X emission after combustion while coal has higher emission. Biomass has carbon life cycle while coal increases CO_2 amount in environment. Biomass is lower energy density feedstock as compared to coal and other energy feedstock. When we use feedstock by combining these two resources, obtain better quality product. Comparsion of different mode for extraction of energy from biomass as shown in figure 9

CONCLUSION

Pakistan's energy requirements are rising constantly due to many reasons. But unfortunately, electricity production is less than electricity demand.

The main reason is that major part of electricity is being producing from natural gas, fossil fuel which are costly energy resources as well as available in limited amount.

That's why irrespective of those resources, Pakistan should also produce energy from all available energy resources to

bridge the gap between production and consumption. Pakistan has a variety of renewable energy resources in bountiful amount but unluckily Pakistan is not making effective use of these energy resources like hydel, solar, coal, biomass & nuclear power.

Due to not well known development in energy production field, Pakistan is facing badly "load shedding". In Pakistan, every sector like people social life, education, economy is badly affected due to worse condition of power shortage.

Many power production projects are still under construction & development due to Informational, technical, economic & social barriers. Pakistan can make progress in power production field, if they make effective and efficient use of all accessible energy resources without any barrier and also implementing various conditions as shown in table-6.

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